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From: Brian Shrager
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To: Ron Myers, U.S. Environmental Protection Agency

Date: November 21, 2003

Project: Hot Mix Asphalt AP-42 Revision

Re: Emission factors for hot oil systems at hot mix asphalt plants

I. INTRODUCTION

The National Asphalt Pavement Association (NAPA) recently conducted an emission testing program to measure formaldehyde and carbon monoxide (CO) emissions from hot oil systems (HOS), which are the systems that heat the hot asphalt oil that is used in the production of hot mix asphalt (HMA). The tests also included measurements of carbon dioxide (CO_2) emissions. Following the recommendation of the United States Environmental Protection Agency (EPA), HOS at four facilities located in North Carolina were selected for testing. EPA approved the site specific test plans (SSTPs) and quality assurance project plan (QAPP) upon which the testing was based. The State of North Carolina was provided the SSTPs and QAPP and provided observers during the emission testing program. This memorandum presents a review and summary of the new HOS emission test report, a discussion of the previously available test data used to develop the current formaldehyde emission factor for hot oil heaters (in AP-42 Section 11.1), and the development of new emission factors that are recommended for inclusion in AP-42 Section 11.1, Hot Mix Asphalt Plants. The HOS test report is included as Appendix A to this memorandum.

II. REVIEW AND SUMMARY OF THE NEW HOS EMISSION TEST REPORT

The following text is proposed for inclusion in the background report for AP-42 Section 11.1, Hot Mix Asphalt Plants:

4.2.1.357 <u>Reference 395</u>. This report includes four separate emission tests that were conducted for NAPA at four hot mix asphalt plants. Each test included three 72-minute test runs that measured formaldehyde and carbon monoxide emissions from hot oil systems (HOS), which are the systems that heat the hot asphalt oil that is used in the production of HMA. Formaldehyde emissions were measured using EPA Method 316, CO emissions were measured using EPA Method 10, and CO_2 emissions were measured using EPA Method 3 (Fyrite analyzer) . The HOS burners were operated at high-fire, constant load conditions during testing, and heat sinks were used to prevent the burners from shutting down during testing. The facilities tested were: (1) S.T. Wooten, Franklinton, NC; (2) S.T. Wooten, Clayton, NC; (3) REA Construction, Mallard Creek, NC; and (4) REA Construction, North Mecklenburg, NC. The following paragraphs discuss unique aspects of each of the individual emission tests.

Testing at S.T. Wooten, Franklinton, NC, was conducted on March 25, 2003. The HOS was fired with No. 2 fuel oil at a rate of 3.0 gallons per hour (gph) during all three test runs. Using the average No. 2 fuel oil heating value documented in AP-42 Section 1.3 (140 million British thermal units [MMBtu] per 1,000 gallons]), this fuel usage rate is equivalent to 0.42 MMBtu/hr. One problem that was reported during the testing was that the Run 1 pre-test flow rate was 12.6 percent greater than the post-test flow rate. This may have introduced a positive bias of up to 12.6 percent on the formaldehyde and CO emissions reported for Run 1. No other problems were reported. The data from this test are assigned a B rating because of the problem documented during Run 1.

Testing at S.T. Wooten, Clayton, NC, was conducted on March 27, 2003. The HOS was fired with No. 2 fuel oil at a rate of 6.5 gph during all three test runs. Using the average No. 2 fuel oil heating value documented in AP-42 Section 1.3 (140 MMBtu per 1,000 gallons]), this fuel usage rate is equivalent to 0.91 MMBtu/hr. Formaldehyde was not detected during Runs 2 and 3, and the detection limits for the two runs were 1.55 parts per billion by volume, dry basis (ppbv), and 1.39 ppbv, respectively. No problems were reported. The formaldehyde data from this test are assigned a B rating because two of the three test runs did not detect formaldehyde, and for purposes of emission factor development, emissions from these two runs were estimated as one-half of the detection limit. The carbon monoxide data from this test are assigned an A rating. The CO_2 data from this test are assigned a B rating because of the relative inaccuracy of Fyrite analyzers (compared to Orsat analyzers).

Testing at REA Construction, Mallard Creek, NC, was conducted on April 1, 2003. The HOS was fired with natural gas at a rate of 1,700 cubic feet per hour (cfh) during all three test runs. Using the average natural gas heating value documented in AP-42 Section 1.4 (1,020 Btu per standard cubic foot [scf]), this fuel usage rate is equivalent to 1.73 MMBtu/hr. In the test report, the maximum natural gas heating value (from AP-42 Section 1.4) of 1,050 Btu/scf was used as a conversion factor, but for purposes of developing emission factors for AP-42, the average value of 1,020 Btu/scf was used. Carbon

monoxide was not detected during any test run at a detection limit of 0.2 parts per million by volume, dry basis (ppmv). No problems were reported. The formaldehyde data from this test are assigned an A rating. The CO data from this test are assigned a B rating because CO was not detected during any test run, and for purposes of emission factor development, a value equal to one-half of the detection limit was used to estimate CO emissions. The CO_2 data from this test are assigned a B rating because of the relative inaccuracy of Fyrite analyzers (compared to Orsat analyzers).

Testing at the REA Construction North Mecklenburg facility was conducted on April 2 and 3, 2003. The HOS was fired with No. 2 fuel oil at a rate of 7.0 gph during all three test runs. Using the average No. 2 fuel oil heating value documented in AP-42 Section 1.3 (140 MMBtu per 1,000 gallons]), this fuel usage rate is equivalent to 0.98 MMBtu/hr. No problems were reported. The formaldehyde and CO data from this test are assigned an A rating. The CO_2 data from this test are assigned a B rating because of the relative inaccuracy of Fyrite analyzers (compared to Orsat analyzers).

III.   DISCUSSION OF PREVIOUSLY AVAILABLE FORMALDEHYDE TEST DATA

The following paragraph is an excerpt from the background report for AP-42 Section 11.1 that presents a brief review of the Reference 35 emission test, which is included as Appendix B to this memorandum, that currently serves as the basis for the hot oil heater formaldehyde emission factor:

"The plant tested was a drum-mix facility with the dryer fired by propane and emissions controlled by a fabric filter. The test included three runs measuring trace metals, total chromium and hexavalent chromium (Cr and Cr^{+6}), PAHs, benzene, toluene, xylene, methyl chloroform, formaldehyde, and hydrogen sulfide emissions from the dryer at the fabric-filter outlet. Also included were three test runs measuring PAHs, polychlorinated dibenzofurans (TCDFs, PCDFs, HxCDFs, HpCDFs, and OCDFs), polychlorinated dibenzo(p)dioxins (TCDDs, PeCDDs, HxCDDs, HpCDDs, and OCDDs), benzene, and formaldehyde emissions from the hot oil heater stack. The hot oil heater was fired with No. 2 fuel oil. Trace metals were measured using draft EPA Method 200.7, and PAHs were tested using EPA MM5 (Semi-VOST). The other pollutants were measured using CARB test procedures, which are similar to EPA methods for the pollutants tested. For target pollutants that were not detected in one or two test runs, emissions from the "nondetect" runs were estimated using one-half of the pollutant detection limit. Several target pollutants were not detected in any run. Radionuclide emissions also were

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sampled during this test, but the information provided is insufficient for emission factor development.

A rating of B was assigned to most of the data from this test. A rating of C was assigned if a pollutant was detected in only one of three test runs. The report included some detail, but it provided only an average production rate and did not describe the control system. The test methodology appeared to be sound, and no problems were reported in the valid test runs."

During the NAPA-sponsored HOS emission tests, we identified additional shortcomings associated with the emission test documented in Reference 35. Most importantly, NAPA recognized prior to testing that HOS are operated with a thermostat that allows the burners to shut down when the oil reaches a specified temperature. The NAPA-sponsored tests included provisions (installation of heat sinks on each burner to prevent the burners from shutting down during testing) to ensure that each HOS system was operating continuously during testing. Without these provisions, the system operation would have been intermittent, resulting in extreme changes in flow and stack gas conditions. It is unclear how the Reference 35 emission test accounted for the intermittent operation of the system, and the results of the test, therefore, are questionable. In addition, Reference 35 does not include any field data sheets, calculations, quality assurance information, description of the test program, or discussion of problems with the testing. Therefore, we recommend that the data for hot oil heaters from Reference 35 be assigned a D rating. Specifically, we recommend that the last paragraph above (shown in *italics*) be replaced with the following paragraph:

For the drum mix dryer emission testing, a rating of B is assigned to most of the data. A rating of C is assigned if a pollutant was detected in only one of three test runs. The report included some detail, but it provided only an average production rate and did not describe the control system. The test methodology appeared to be sound, and no problems were reported in the valid test runs. The hot oil heater emission test data are assigned a D rating because of the lack of documentation and, more importantly, the large amount of uncertainty associated with the testing and how the testing accounted for the intermittent operation of the system and the resultant changes in exhaust flow and stack gas conditions.

IV.   DEVELOPMENT OF NEW EMISSION FACTORS FOR HOS

The following paragraphs are proposed to replace the existing section 4.2.4.2 in the background report for AP-42 Section 11.1:

    4.2.4.2 <u>Hot Oil Systems</u>. Emission factors for HOS, which are the systems that heat the hot asphalt oil that is used in the production of HMA, were developed using the data presented in Table 4-13. Table 4-13a shows the development of emission factors for formaldehyde, CO, and CO_2 (pollutants for which more than one test is available). The formaldehyde, CO, and CO_2 emission factors for each test were calculated with units of kilogram per liter (kg/l) (pounds per gallon [lb/gal]) for oil-fired HOS and kilogram per standard cubic meter (kg/m^3) (pounds per standard cubic foot lb/ft^3) for natural gas-fired HOS. These emission factors then were normalized to a common basis, pounds per MMBtu (lb/MMBtu), so that the data for fuel oil-fired and natural gas-fired HOS could be compared and combined (if appropriate). The normalized average emission factors were then converted back to a kg/l (lb/gal) basis for fuel oil fired HOS and a kg/m^3 (lb/ft^3) basis for natural gas-fired HOS. The average emission factors for HOS are shown in Table 4-18. The following paragraphs describe the emission factor development.

    Uncontrolled emission factors for PAHs and several polychlorinated dibenzofurans and dibenzo(p)dioxins, including 1,2,3,7,8,9-HxCDD, 1,2,3,4,7,8-HxCDD, total HxCDD, 1,2,3,4,6,7,8-HpCDD, total HpCDD, total OCDD, total TCDF, total PeCDF, total HxCDF, total HpCDF, 1,2,3,4,6,7,8-HpCDF, and total OCDF were developed from a single D-rated test. These emission factors are assigned E ratings.

    Emission factors for uncontrolled formaldehyde emissions from HOS were developed from two A-rated and two B-rated tests conducted at four facilities. Data from one additional D-rated test, Reference 35, were not used for emission factor development because, as specified in the AP-42 procedures manual, C- or D-rated data should not be combined with A- or B-rated data. The formaldehyde data (from HOS fired by different fuels) were first normalized to a lb/MMBtu basis, and, because the emission factors were similar regardless of the HOS fuel type, the data from all four tests were combined to develop a single formaldehyde emission factor for HOS. This average lb/MMBtu emission factor then was converted back to a kg/l (lb/gal) basis for fuel oil-fired HOS and a kg/m^3 (lb/ft^3) basis for natural gas-fired HOS. These formaldehyde emission factors are assigned a C rating.

    An emission factor for uncontrolled CO emissions from HOS was developed from three A-rated tests and one B-rated test conducted at four facilities. The CO data were first normalized to a lb/MMBtu basis, and the data from all four tests were combined to develop a single CO emission factor for HOS. The

average lb/MMBtu emission factor then was converted back to a kg/l (lb/gal) basis for fuel oil-fired HOS and a kg/m^3 (lb/ft^3) basis for natural gas-fired HOS. The CO emission factors are assigned a C rating.

An emission factor for uncontrolled CO_2 emissions from HOS was developed from four B-rated tests conducted at four facilities. The CO_2 data were first normalized to a lb/MMBtu basis, and, because the emission factors were similar regardless of the HOS fuel type, the data from all four tests were combined to develop a single CO_2 emission factor for HOS. The average lb/MMBtu emission factor then was converted back to a kg/l (lb/gal) basis for fuel oil-fired HOS and a kg/m^3 (lb/ft^3) basis for natural gas-fired HOS. These CO_2 emission factors are assigned a C rating.

Table 4-13. SUMMARY OF TEST DATA FOR HOT MIX ASPHALT PRODUCTION HOT OIL SYSTEMS

Type of control	Fuel fired	Pollutant	No. of test runs	Data rating	Emission factor range, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Average emission factor, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Ref. No.
None	No. 2 fuel oil	Naphthalene	3	D	1.2×10^{-6}-2.8×10^{-6} (1.1×10^{-5}-2.3×10^{-5})	2.0×10^{-6} (1.7×10^{-5})	35
None	No. 2 fuel oil	Acenaphthylene	3	D	1.7×10^{-8}-3.0×10^{-8} (1.4×10^{-7}-2.5×10^{-7})	2.4×10^{-8} (2.0×10^{-7})	35
None	No. 2 fuel oil	Acenaphthene	3	D	6.2×10^{-8}-6.7×10^{-8} (5.2×10^{-7}-5.6×10^{-7})	6.4×10^{-8} (5.3×10^{-7})	35
None	No. 2 fuel oil	Fluorene	3	D	1.6×10^{-7}-4.6×10^{-7} (1.3×10^{-6}-3.8×10^{-6})	2.8×10^{-7} (2.3×10^{-6})	35
None	No. 2 fuel oil	Phenanthrene	3	D	4.8×10^{-7}-8.2×10^{-7} (4.0×10^{-6}-6.8×10^{-6})	5.9×10^{-7} (4.9×10^{-6})	35
None	No. 2 fuel oil	Anthracene	3	D	1.7×10^{-8}-2.9×10^{-8} (1.4×10^{-7}-2.4×10^{-7})	2.2×10^{-8} (1.8×10^{-7})	35
None	No. 2 fuel oil	Fluoranthene	3	D	3.4×10^{-9}-6.2×10^{-9} (2.8×10^{-8}-5.2×10^{-8})	5.3×10^{-9} (4.4×10^{-8})	35
None	No. 2 fuel oil	Pyrene	3	D	3.2×10^{-9}-4.7×10^{-9} (2.7×10^{-8}-3.9×10^{-8})	3.8×10^{-9} (3.2×10^{-8})	35
None	No. 2 fuel oil	Benzo(b)fluoranthene	3	D	7.2×10^{-9}-1.8×10^{-8} (6.0×10^{-8}-1.5×10^{-7})	1.2×10^{-8} (1.0×10^{-7})	35
None	No. 2 fuel oil	TCDF (total)	3	D	6.7×10^{-14}-8.2×10^{-13} (5.6×10^{-13}-6.8×10^{-12})	4.0×10^{-13} (3.3×10^{-12})	35
None	No. 2 fuel oil	PCDF (total)	3	D	2.4×10^{-14}-1.2×10^{-13} (2.0×10^{-13}-1.0×10^{-12})	5.8×10^{-14} (4.8×10^{-13})	35
None	No. 2 fuel oil	HxCDF (total)	2	D	1.6×10^{-14}-5.8×10^{-13} (1.3×10^{-13}-4.8×10^{-12})	2.4×10^{-13} (2.0×10^{-12})	35
None	No. 2 fuel oil	HpCDF (total)	2	D	3.8×10^{-14}-2.6×10^{-12} (3.2×10^{-13}-2.2×10^{-11})	1.2×10^{-12} (9.7×10^{-12})	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDF	3	D	9.4×10^{-14}-1.0×10^{-12} (7.6×10^{-13}-8.4×10^{-12})	4.2×10^{-13} (3.5×10^{-12})	35
None	No. 2 fuel oil	OCDF	3	D	1.2×10^{-13}-3.7×10^{-12} (1.0×10^{-12}-3.1×10^{-11})	1.4×10^{-12} (1.2×10^{-11})	35
None	No. 2 fuel oil	HxCDD (total)	3	D	2.3×10^{-13}-1.3×10^{-12} (1.9×10^{-12}-1.1×10^{-11})	7.4×10^{-13} (6.2×10^{-12})	35
None	No. 2 fuel oil	1,2,3,7,8,9-HxCDD	3	D	3.8×10^{-14}-1.2×10^{-13} (3.2×10^{-13}-1.0×10^{-12})	9.1×10^{-14} (7.6×10^{-13})	35
None	No. 2 fuel oil	1,2,3,4,7,8-HxCDD	3	D	3.8×10^{-14}-1.1×10^{-13} (3.2×10^{-13}-9.2×10^{-13})	8.3×10^{-14} (6.9×10^{-13})	35
None	No. 2 fuel oil	HpCDD (total)	3	D	1.7×10^{-13}-6.7×10^{-12} (1.4×10^{-12}-5.6×10^{-11})	2.4×10^{-12} (2.0×10^{-11})	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDD	3	D	1.7×10^{-13}-4.6×10^{-12} (1.4×10^{-12}-3.8×10^{-11})	1.8×10^{-12} (1.5×10^{-11})	35
None	No. 2 fuel oil	OCDD	3	D	1.2×10^{-12}-5.3×10^{-11} (1.0×10^{-11}-4.4×10^{-10})	1.9×10^{-11} (1.6×10^{-10})	35
None	No. 2 fuel oil	Formaldehyde	3	D	0.0019-0.0053 (0.016-0.044)	0.0032 (0.027)	35

TABLE 4-13. (continued)

Type of control	Fuel fired	Pollutant	No. of test runs	Data rating	Emission factor range, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Average emission factor, kg/l (lb/gal) fuel consumed (unless noted otherwise)	Ref. No.
None	No. 2 fuel oil	Formaldehyde	3	B	7.1×10^{-7}-1.4×10^{-6} (6.0×10^{-6}-1.2×10^{-5})	9.4×10^{-7} (7.9×10^{-6})	395[a]
None	No. 2 fuel oil	Carbon monoxide	3	A	8.3×10^{-5}-0.00089 (0.00070-0.0075)	0.00043 (0.0036)	395[a]
None	No. 2 fuel oil	Carbon dioxide	3	B	2.4-2.6 (20-22)	2.5 (21)	395[a]
None	No. 2 fuel oil	Formaldehyde	3	B	1.9×10^{-8}-8.6×10^{-8} (1.6×10^{-7}-7.2×10^{-7})	4.2×10^{-8} (3.5×10^{-7})	395[b]
None	No. 2 fuel oil	Carbon monoxide	3	A	2.8×10^{-5}-7.0×10^{-5} (0.00024-0.00059)	4.6×10^{-5} (0.00039)	395[b]
None	No. 2 fuel oil	Carbon dioxide	3	B	4.3-4.5 (36-38)	4.4 (37)	395[b]
None	Natural gas	Formaldehyde	3	A	kg/m^3 (lb/ft^3) 9.8×10^{-8}-3.5×10^{-7} (6.1×10^{-9}-2.2×10^{-8})	kg/m^3 (lb/ft^3) 2.6×10^{-7} (1.6×10^{-8})	395[c]
None	Natural gas	Carbon monoxide	3	B	kg/m^3 (lb/ft^3) 1.9×10^{-6}-1.9×10^{-6} (1.2×10^{-7}-1.2×10^{-7})	kg/m^3 (lb/ft^3) 1.9×10^{-6} (1.2×10^{-7})	395[c]
None	Natural gas	Carbon dioxide	3	B	kg/m^3 (lb/ft^3) 2.7-2.7 (0.17-0.17)	kg/m^3 (lb/ft^3) 2.7 (0.17)	395[c]
None	No. 2 fuel oil	Formaldehyde	3	A	1.7×10^{-7}- 8.0×10^{-7} (1.4×10^{-6}-6.7×10^{-6})	4.0×10^{-7} (3.4×10^{-6})	395[d]
None	No. 2 fuel oil	Carbon monoxide	3	A	6.2×10^{-5}-0.00013 (0.00052-0.0011)	9.9×10^{-5} (0.00083)	395[d]
None	No. 2 fuel oil	Carbon dioxide	3	B	3.2-3.6 (27-30)	3.3 (28)	395[d]

[a] S.T. Wooten, Franklinton, NC, facility.
[b] S.T. Wooten, Clayton, NC, facility.
[c] REA Construction, Mallard Creek, NC, facility.
[d] REA Construction, North Mecklenburg, NC facility.

Table 4-13a. SUMMARY OF EMISSION FACTOR DEVELOPMENT FOR FORMALDEHYDE, CARBON MONOXIDE, AND CARBON DIOXIDE FROM HOT MIX ASPHALT PRODUCTION – HOT OIL SYSTEMS

Type of control	Fuel fired	Pollutant	No. of tests	Emission factor rating	Average emission factor, kg/l (lb/gal) fuel consumed (unless noted)	Converted emission factor, lb/MMBtu	Average emission factor, lb/MMBtu	Candidate emission factors and units	Ref. No.
~~None~~	~~No. 2 fuel oil~~	~~Formaldehyde~~			~~0.0032 (0.027)~~	~~NA~~			~~35~~
None	No. 2 fuel oil	Formaldehyde			4.2×10^{-8} (3.5×10^{-7})	2.5×10^{-6}	2.5×10^{-5}	Fuel oil-fired HOS 4.2×10^{-7} kg/l (3.5×10^{-6} lb/gal) Natural gas-fired HOS 4.1×10^{-7} kg/m^3 (2.6×10^{-8} lb/ft^3)	395[b]
None	Natural gas	Formaldehyde	4	C	kg/m^3 (lb/ft^3) 2.6×10^{-7} (1.6×10^{-8})	1.6×10^{-5}			395[c]
None	No. 2 fuel oil	Formaldehyde			4.0×10^{-7} (3.4×10^{-6})	2.5×10^{-5}			395[d]
None	No. 2 fuel oil	Formaldehyde			9.4×10^{-7} (7.9×10^{-6})	5.7×10^{-5}			395[a]
None	Natural gas	Carbon monoxide	4	C	kg/m^3 (lb/ft^3) 1.9×10^{-6} (1.2×10^{-7})	0.00012	0.0087	Fuel oil-fired HOS 0.00015 kg/l (0.0012 lb/gal) Natural gas-fired HOS 0.00014 kg/m^3 (8.9×10^{-6} lb/ft^3)	395[c]
None	No. 2 fuel oil	Carbon monoxide			4.6×10^{-5} (0.00039)	0.0028			395[b]
None	No. 2 fuel oil	Carbon monoxide			9.9×10^{-5} (0.00083)	0.0059			395[d]
None	No. 2 fuel oil	Carbon monoxide			0.00043 (0.0036)	0.026			395[a]
None	No. 2 fuel oil	Carbon dioxide	4	C	2.5 (21)	150	200	Fuel oil-fired HOS 3.4 kg/l (28 lb/gal) Natural gas-fired HOS 3.3 kg/m^3 (0.20 lb/ft^3)	395[a]
None	Natural gas	Carbon dioxide			kg/m^3 (lb/ft^3) 2.7 (0.17)	170			395[c]
None	No. 2 fuel oil	Carbon dioxide			3.3 (28)	200			395[d]
None	No. 2 fuel oil	Carbon dioxide			4.4 (37)	260			395[b]

[a] S.T. Wooten, Franklinton, NC, facility.
[b] S.T. Wooten, Clayton, NC, facility.
[c] REA Construction, Mallard Creek, NC, facility.
[d] REA Construction, North Mecklenburg, NC facility.

Table 4-18. SUMMARY OF EMISSION FACTOR DEVELOPMENT FOR HOT MIX ASPHALT
PRODUCTION DRUM MIX FACILITY – HOT OIL HEATERS

Type of control	Fuel fired	Pollutant	No. of tests	Emission factor rating	Average emission factor, kg/l (lb/gal) fuel consumed, unless noted otherwise	Ref. No.
None	No. 2 fuel oil	Naphthalene	1	E	2.0×10^{-6} (1.7×10^{-5})	35
None	No. 2 fuel oil	Acenaphthylene	1	E	2.4×10^{-8} (2.0×10^{-7})	35
None	No. 2 fuel oil	Acenaphthene	1	E	6.4×10^{-8} (5.3×10^{-7})	35
None	No. 2 fuel oil	Fluorene	1	E	2.8×10^{-7} (2.3×10^{-6})	35
None	No. 2 fuel oil	Phenanthrene	1	E	5.9×10^{-7} (4.9×10^{-6})	35
None	No. 2 fuel oil	Anthracene	1	E	2.2×10^{-8} (1.8×10^{-7})	35
None	No. 2 fuel oil	Fluoranthene	1	E	5.3×10^{-9} (4.4×10^{-8})	35
None	No. 2 fuel oil	Pyrene	1	E	3.8×10^{-9} (3.2×10^{-8})	35
None	No. 2 fuel oil	Benzo(b)fluoranthene	1	E	1.2×10^{-8} (1.0×10^{-7})	35
None	No. 2 fuel oil	TCDF (total)	1	E	4.0×10^{-13} (3.3×10^{-12})	35
None	No. 2 fuel oil	PCDF (total)	1	E	5.8×10^{-14} (4.8×10^{-13})	35
None	No. 2 fuel oil	HxCDF (total)	1	E	2.4×10^{-13} (2.0×10^{-12})	35
None	No. 2 fuel oil	HpCDF (total)	1	E	1.2×10^{-12} (9.7×10^{-12})	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDF	1	E	4.2×10^{-13} (3.5×10^{-12})	35
None	No. 2 fuel oil	OCDF	1	E	1.4×10^{-12} (1.2×10^{-11})	35
None	No. 2 fuel oil	HxCDD (total)	1	E	7.4×10^{-13} (6.2×10^{-12})	35
None	No. 2 fuel oil	1,2,3,7,8,9-HxCDD	1	E	9.1×10^{-14} (7.6×10^{-13})	35
None	No. 2 fuel oil	1,2,3,4,7,8-HxCDD	1	E	8.3×10^{-14} (6.9×10^{-13})	35
None	No. 2 fuel oil	HpCDD (total)	1	E	2.4×10^{-12} (2.0×10^{-11})	35
None	No. 2 fuel oil	1,2,3,4,6,7,8-HpCDD	1	E	1.8×10^{-12} (1.5×10^{-11})	35
None	No. 2 fuel oil	OCDD	1	E	1.9×10^{-11} (1.6×10^{-10})	35
None	No. 2 fuel oil	Formaldehyde	4	C	4.2×10^{-7} (3.5×10^{-6})	395
None	No. 2 fuel oil	CO	4	C	0.00015 (0.0012)	395
None	No. 2 fuel oil	CO_2	4	C	3.4 (28)	395
None	Natural gas	Formaldehyde	4	C	4.1×10^{-7} kg/m^3 $(2.6 \times 10^{-8}$ lb/ft$^3)$	395
None	Natural gas	CO	4	C	0.00014 kg/m^3 $(8.9 \times 10^{-6}$ lb/ft$^3)$	395
None	Natural gas	CO_2	4	C	3.3 kg/m^3 (0.20 lb/ft^3)	395

V. PROPOSED CHANGES TO AP-42 SECTION 11.1

Based on the new information provided in this memorandum, RTI recommends revising Table 11.1.13 in AP-42 Section 11.1 as shown on the following page. RTI also recommends adding the following reference citation to the list of references in AP-42 Section 11.1:

395.   Test Report. Formaldehyde Emissions Testing from Asphalt Heaters. Prepared for: National Asphalt Pavement Association, Lanham, MD. MACTEC Federal Programs, Inc., Research Triangle Park, NC. October 2003.

Proposed Table 11.1-13. EMISSION FACTORS FOR HOT MIX ASPHALT HOT OIL SYSTEMS[a]

| Process | Pollutant | | Emission factor | Emission factor units | EMISSION FACTOR RATING | Reference |
	CASRN	Name				
Hot oil system fired with natural gas (SCC 3-05-002-06)	630-08-0	Carbon monoxide	8.9×10^{-6}	lb/ft^3	C	395
	124-38-9	Carbon dioxide	0.20	lb/ft^3	C	395
	50-00-0	Formaldehyde	2.6×10^{-8}	lb/ft^3	C	395
Hot oil system fired with No. 2 fuel oil (SCC 3-05-002-08)	630-08-0	Carbon monoxide	0.0012	lb/gal	C	395
	124-38-9	Carbon dioxide	28	lb/gal	C	395
	50-00-0	Formaldehyde	3.5×10^{-6}	lb/gal	C	395
	83-32-9	Acenaphthene[b]	5.3×10^{-7}	lb/gal	E	35
	208-96-8	Acenaphthylene[b]	2.0×10^{-7}	lb/gal	E	35
	120-12-7	Anthracene[b]	1.8×10^{-7}	lb/gal	E	35
	205-99-2	Benzo(b)fluoranthene[b]	1.0×10^{-7}	lb/gal	E	35
	206-44-0	Fluoranthene[b]	4.4×10^{-8}	lb/gal	E	35
	86-73-7	Fluorene[b]	3.2×10^{-8}	lb/gal	E	35
	91-20-3	Naphthalene[b]	1.7×10^{-5}	lb/gal	E	35
	85-01-8	Phenanthrene[b]	4.9×10^{-6}	lb/gal	E	35
	129-00-0	Pyrene[b]	3.2×10^{-8}	lb/gal	E	35
		Dioxins				
	19408-74-3	1,2,3,7,8,9-HxCDD[b]	7.6×10^{-13}	lb/gal	E	35
	39227-28-6	1,2,3,4,7,8-HxCDD[b]	6.9×10^{-13}	lb/gal	E	35
		HxCDD[b]	6.2×10^{-12}	lb/gal	E	35
	35822-46-9	1,2,3,4,6,7,8-HpCDD[b]	1.5×10^{-11}	lb/gal	E	35
		HpCDD[b]	2.0×10^{-11}	lb/gal	E	35
	3268-87-9	OCDD[b]	1.6×10^{-10}	lb/gal	E	35
		Total PCDD	2.0×10^{-10}	lb/gal	E	35
		Furans				
		TCDF[b]	3.3×10^{-12}	lb/gal	E	35
		PeCDF[b]	4.8×10^{-13}	lb/gal	E	35
		HxCDF[b]	2.0×10^{-12}	lb/gal	E	35
		HpCDF[b]	9.7×10^{-12}	lb/gal	E	35
	67562-39-4	1,2,3,4,6,7,8-HpCDF[b]	3.5×10^{-12}	lb/gal	E	35
	39001-02-0	OCDF[b]	1.2×10^{-11}	lb/gal	E	35
		Total PCDF	3.1×10^{-11}	lb/gal	E	35
		Total PCDD/PCDF	2.3×10^{-10}	lb/gal	E	35

[a] Emission factor units are lb/gal of fuel consumed. To convert from pounds per standard cubic foot (lb/ft$^{3)}$) to kilograms per standard cubic meter (kg/m$^{3)}$), multiply by 16. To convert from lb/gal to kilograms per liter (kg/l), multiply by 0.12. CASRN = Chemical Abstracts Service Registry Number. SCC = Source Classification Code.

[b] Compound is classified as polycyclic organic matter, as defined in the 1990 Clean Air Act Amendments (CAAA). Total PCDD is the sum of the total tetra through octa dioxins; total PCDF is sum of the total tetra through octa furans; and total PCDD/PCDF is the sum of total PCDD and total PCDF.

APPENDIX A.

AP-42 SECTION 11.1, PROPOSED REFERENCE 395

Test Report. Formaldehyde Emissions Testing from Asphalt Heaters. Prepared for: National Asphalt Pavement Association, Lanham, MD. MACTEC Federal Programs, Inc., Research Triangle Park, NC. October 2003.

APPENDIX B.

AP-42 SECTION 11.1, REFERENCE 35